

WL-TR-95-5042



## **NOVEL LARGE AREA, HIGH THROUGHPUT, HIGH RESOLUTION, PATTERNING SYSTEM PROGRAM**

### **PROGRAM SUMMARY**

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August 1995

### **SUMMARY**

September 13, 1995 - June 23, 1995

19960304 092

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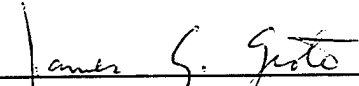
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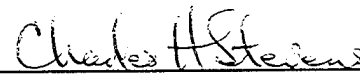
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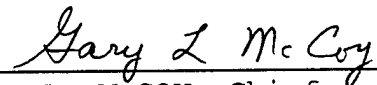
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<b>REPORT DOCUMENTATION PAGE</b>		<b>Form Approved GMB No. 0704-0188</b>	
Public reporting burden for this collection of information is estimated to average 110 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.			
1. Agency Use Only (Leave Blank)	2. Report Date 22 Aug 1995	3. Report Type and Dates Covered Final - 13 Sept 95 - 23 Jun 95	
4. Title and Subtitle Novel Large Area, High Throughput, High Resolution Patterning Sys. Program; Program Summary		5. Funding Numbers C: F33615-93-C-1331 PE: 62301E & 63739E PR: 9316 TA: 02 WU: 01	
6. Author(s) Dr. Kanti Jain and Greg Lievan			
7. Performing Organization Name(s) and Address(es) Texas Instruments Inc      Anvik Corporation P.O. Box 655012              250 Clearbrook Dallas, TX 75265              Elmsford, NY 10523		8. Performing Organization Report Number	
9. Sponsoring/Monitoring Agency Name(s) and Address(es) Solid State Electronics Directorate Wright Laboratory Materiel Command (AFMC) Wright-Patterson AFB, OH 45433-7331		10. Sponsoring/Monitoring Agency  WL-TR-95-5042	
11. Supplementary Notes This effort was funded by ARPA/ESTO, 3701 N. Fairfax Drive, Arlington, VA 22203-1714. The effort is Phase IB of the ARPA ASEM Program.			
12a. Distribution/Availability Statement Approved for Public Release; Distribution is Unlimited.		12b. Distribution Code	
13. Abstract (Maximum 200 words) The objective of this phase ia program is to demonstrate a concept for a high resolution ultra violet (UV) based optical patterning system technology for production of both electronic and electro-optical multichip modules (MCMs) and flat panel displays. The tasks identify patterning system requirements, investigate different optical and mechanical design options, perform comparative analysis of design options, procure hardware, demonstrate large area patterning, procure masks, conduct via etching experiments, perform cost study, and determine limits of the system. A proof-of-concept patterning system was assembled. It was used to demonstrate large-area seamless patterning using multiple, partially overlapping scans. For patterning resists, the system demonstrated good resolution down to 3 $\mu\text{m}$ . For ablation of polyimide, vias showed excellent resolution down to 10 $\mu\text{m}$ . Ablation of 6 $\mu\text{m}$ wide lines and spaces was demonstrated.			
14. Subject Terms Processing, Precision Fabrication, Laser Applications, Excimer Laser Lithography		15. Number of Pages 7	
		16. Price Code	
17. Security Classification of Report UNCLASSIFIED	18. Security Classification of this Page UNCLASSIFIED	19. Security Classification of Abstract UNCLASSIFIED	20. Limitation of Abstract UNLIMITED

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## **1. Introduction**

In the manufacturing of multichip modules (MCM's) and other high-performance electronic packages, patterning of the various resist, dielectric, and metal layers constitutes the most important segment of the total fabrication process. Currently used patterning and via-drilling methods suffer from several inherent disadvantages. Anvik's novel large-area patterning technology offers a breakthrough that overcomes the limitations of existing methods and achieves the combined capabilities of large field size, high resolution, and high throughput. The goal of this ARPA-sponsored Texas Instruments-Anvik program is to develop Anvik's technology into advanced manufacturing equipment that will significantly improve the cost-effectiveness of high-volume manufacturing of MCM's, flat-panel displays, and printed circuit boards.

The key objectives of the Phase 1A effort were to carry out risk reduction tasks and establish technical feasibility by designing, building, and demonstrating a proof-of-concept patterning and via-drilling system prototype. The goals in Phase 1B were to conduct detailed experiments to demonstrate the full advantages of the new technology. This work is in preparation for a possible follow-on effort, which will be devoted to designing, building, and testing a production-worthy hardware prototype of the proposed system.

## 2. Summary and Results

This Summary Report provides an overview of the development and characterization of a proof-of-concept large-area patterning and via-drilling system prototype. In Phase 1A, an investigation of patterning requirements for different applications was conducted, and an analysis of different design configurations to meet those requirements was given. Based on this analysis, a proof-of-concept prototype was designed and assembled. We successfully demonstrated our seamless scanning technique for exposure of photoresist as well as photoablation of interlayer dielectric materials. In Phase 1B, the system hardware, control software, and alignment techniques were upgraded to give diffraction-limited resolution of  $3\text{ }\mu\text{m}$  in photoresist over a full  $5 \times 5$  inch substrate with Anvik's seamless scanning technique. Photoablation of  $10\text{ }\mu\text{m}$  vias and  $6\text{ }\mu\text{m}$  lines and spaces was demonstrated in polyimide. Detailed resist exposure experiments were conducted to study different resists and optimize the processing parameters. Detailed experiments on photoablation were also conducted using different dielectric materials; this work required the use and characterization of multilayer dielectric masks.

The design concept chosen is based on the use of a single, planar scanning stage on which both the mask and the substrate are mounted. This configuration is shown in Fig. 1. The mask is illuminated with a hexagonal illumination pattern produced by an illumination system situated below the mask. The illuminated region of the mask is imaged with a projection lens and several beam-folding mirrors to produce an image of the illuminated mask region on the substrate. Note that the optical axis through the projection lens is in a horizontal plane, and a reversing assembly is used in the imaging path to undo the image reversal caused by the lens. This produces an image on the substrate in the same orientation as the mask pattern, which enables the use of a single stage. It is readily seen that this design approach is highly modular, in the sense that each of the main subsystems, namely, the projection system, the illumination system, and the stage system, can be separately optimized and an overall system configuration most suitable for any given application can be assembled.

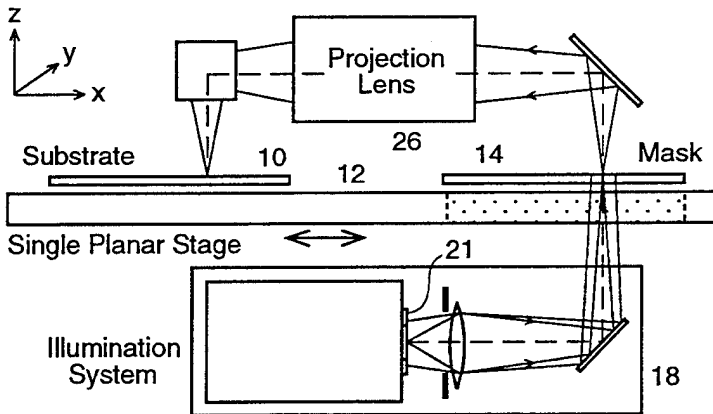
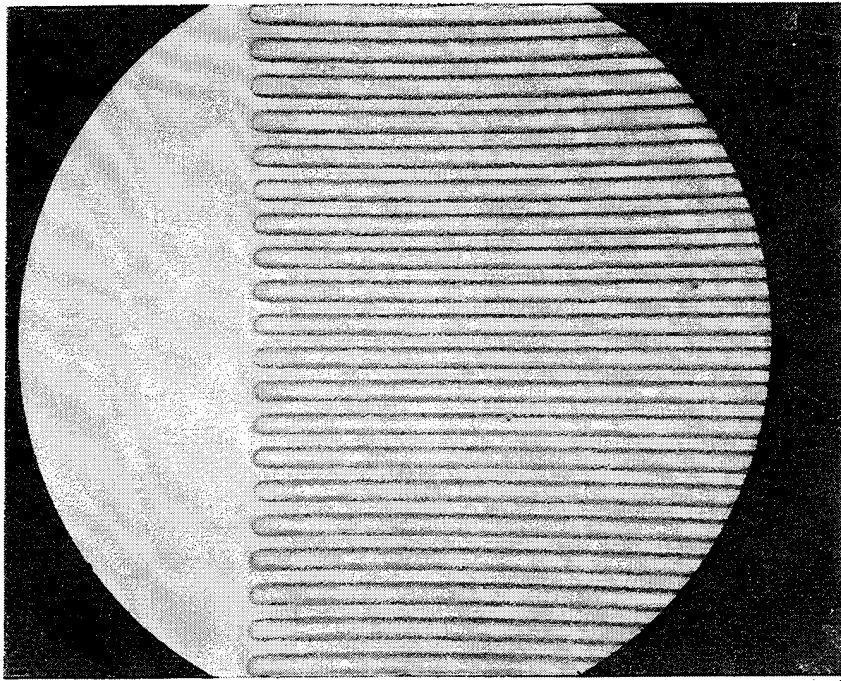
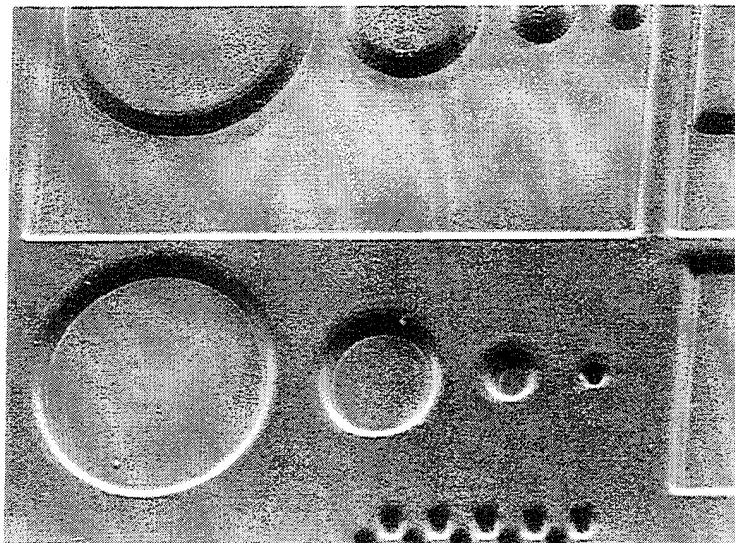


Fig. 1. Anvik's large-area, high-throughput lithography and via-drilling system, showing a board and a mask held rigidly on a single planar stage, an illumination system, and a projection lens.

In Figs. 2 and 3, we show some of the excellent patterning results achieved using the Anvik lithography tool. We show results from both patterning of photoresists and via-drilling in polyimide. Figure 2 shows good  $3\text{ }\mu\text{m}$  imagery in  $1.1\text{ }\mu\text{m}$  thick UCB-JSR TI 080 photoresist. This resolution was achieved across the entire substrate with no seams as a result of the scanning hexagonal illumination. In Fig. 3 we show the results of photo-etching in  $8.3\text{ }\mu\text{m}$  thick Pyralin PI 2611D polyimide by excimer ablation, showing patterning of  $100$ ,  $50$ , and  $10\text{ }\mu\text{m}$  vias and a checkerboard pattern of  $10\text{ }\mu\text{m}$  square vias. For both resist exposure and via-drilling, we demonstrated a throughput advantage of 5X over current lithography tools.



*Fig. 2. Results obtained with the Anvik prototype system showing resolution of 3  $\mu\text{m}$  lines and spaces patterned in JSR TI 080 resist.*



*Fig. 3. Scanning electron micrograph showing patterns ablated in Dupont Pyralin PI 2611D polyimide. The bottom row shows 100, 50, 20, and 10  $\mu\text{m}$  round vias and a checkerboard pattern of 10  $\mu\text{m}$  square vias. The top row shows pillars of the same dimensions.*

### **3. Conclusion**

In this Phase 1 program, we have successfully demonstrated the feasibility of Anvik's patterning technology. We have fully assembled a proof-of-concept patterning system and demonstrated large-area seamless patterning using multiple, partially overlapping scans. We have also carried out seamless, scan-and-repeat exposure of polyimide to demonstrate large-area batch drilling of vias. For patterning in resist, we have demonstrated good resolution of 3 micron lines and spaces, and for via ablation in polyimide, we have drilled 10  $\mu\text{m}$  vias and 6  $\mu\text{m}$  lines and spaces with excellent resolution.